Consumption Heterogeneity: Micro Drivers and Macro Implications

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Norges Bank, Danmarks Nationalbank and Deutsche Bundesbank conference on Heterogeneous households, firms and financial intermediaries
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Is Heterogeneity Important for Macroeconomics?

Theory: Consumption heterogeneity is *potentially* very important for macroeconomic dynamics

- e.g. Recent HANK models

Macroeconomic events can redistribute wealth between High and Low MPC households, affecting aggregate consumption

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Macroeconomic events can redistribute wealth between High and Low MPC households, affecting aggregate consumption

Empirics: Testing and quantifying these effects often boils down to measuring the distribution of MPC along some dimension of redistribution

Ability to do so is limited by:

- Methods to measure MPCs
- Consumption data
- Household balance sheet data

What does this paper do?

Two Empirical Contributions

1. **Method:** New methodology to measure MPCs out of transitory and permanent income shocks
   - Builds on Blundell, Pistaferri, and Preston (2008)
   - Correctly accounts for the Time Aggregation Problem

2. **Data:** Panel data covering all Danish households 2004-2015
   - Large sample size reveals clear, systemic heterogeneity
   - Detailed household balance sheets allow us to infer implications for monetary policy transmission

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   - Large sample size reveals clear, systemic heterogeneity
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We also test to what extent a buffer-stock model can fit the observed distribution of MPC with liquid wealth

What does this paper find?

Wealthy Hand-to-Mouth

Poor Hand-to-Mouth

Wealthy

What does this paper find?

Wealthy Hand-to-Mouth

MPC ≈ 0.5

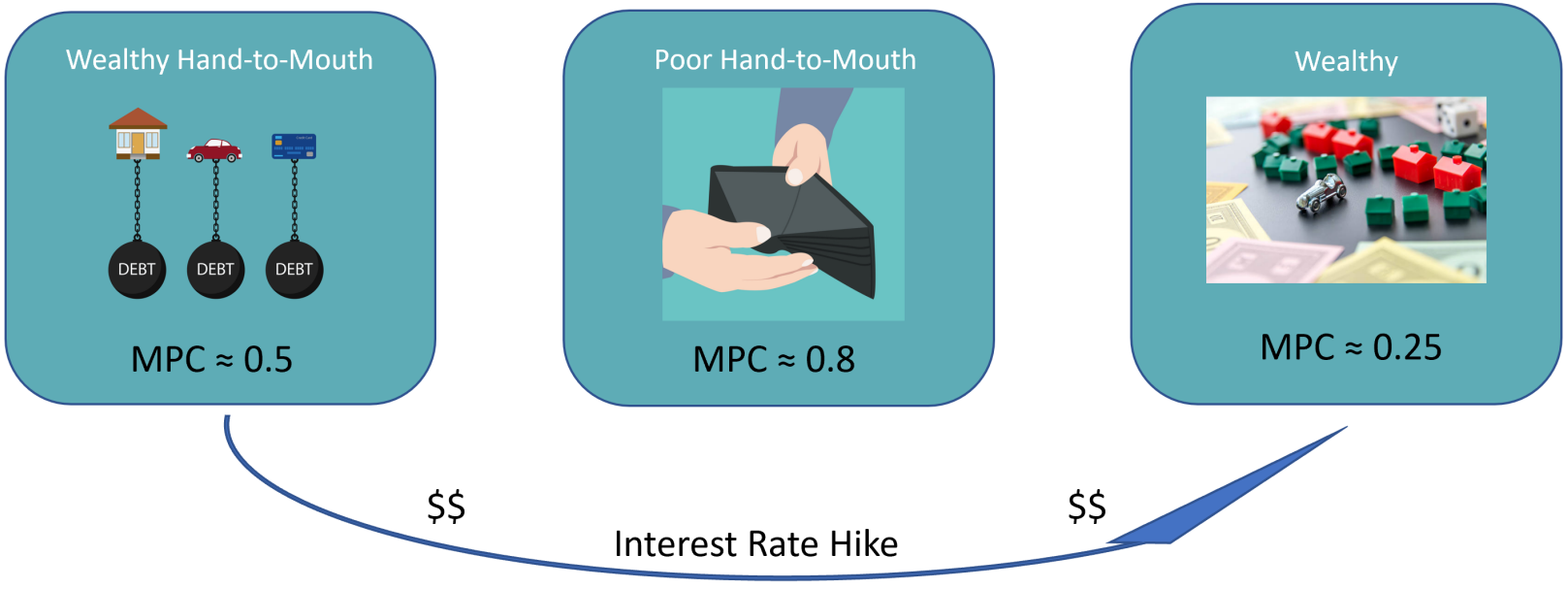
Poor Hand-to-Mouth

MPC ≈ 0.8

Wealthy

MPC ≈ 0.25

What does this paper find?



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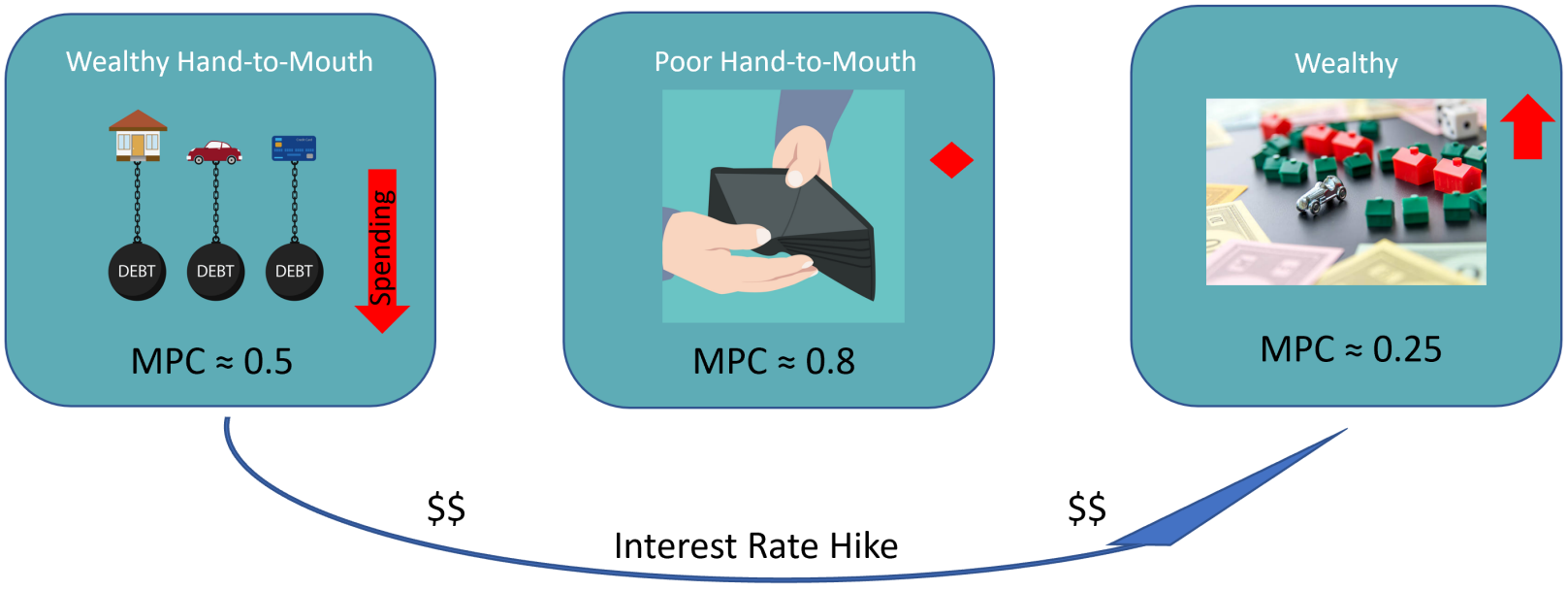

A **one percentage point** interest rate hike reduces aggregate expenditure by **26 basis points** through this ***interest rate exposure channel*** alone

Redistribution > Intertemporal Substitution

What has the Empirical MPC literature Found?

General consensus: **MPCs are large** (≈ 0.5 including durables)

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Few studies have enough power to say much about the distribution of MPCs in the population

- Jappelli and Pistaferri (2014) Italian Survey Data
- Fuster, Kaplan, and Zafar (2018) NY Fed Survey
- Fagereng, Holm, and Natvik (2016) Norway Lottery Data
- Gelman (2016) Financial App Data

Liquid assets and **income** are key predictors of transitory MPC

Our method and data can uncover detailed heterogeneity - Many potential applications

How Are Consumption Responses Typically Measured?

Three methods:

1. (Natural) Experiments - stimulus checks, lotteries etc
   - Few true experiments, especially for permanent shocks
   - Data limitations
2. Ask people
   - Unclear how to interpret
3. Make identifying restrictions on income and consumption dynamics
   - Empirical methods (until now!) have been flawed

We develop a robust method based on 3

Relation to BPP

Identification: Income

Income flow consists of:

- Permanent Income (random walk)
- Transitory Income (persistence $<$ 2 years)

$$\bar{y}_T = \int_{T-1}^{T} p_t dt + \int_{T-1}^{T} \int_{t-2}^{t} f(t-s) dq_s dt$$

$$\Longrightarrow \ \mathrm{Var}(\Delta^N \bar{y}_T) = (N - \frac{1}{3})\sigma_p^2 + 2\sigma_{\tilde{q}}^2 \text{ for } N \geq 3$$

Details on income process

Identification: Consumption

Assumptions on Consumption

- Permanent: Consumption permanently moves by fraction ϕ of the income shock
- Transitory: Persistence $<$ 2 years

$$c_t = \phi p_t + \int_{t-2}^{t} g(t-s)dq_s$$

$$\implies \text{Cov}(\Delta^N \bar{c_T}, \Delta^N \bar{y_T}) = \phi(N - \frac{1}{3})\sigma_p^2 + 2\psi\sigma_{\tilde{q}}^2$$

where $\psi = \frac{\text{Cov}(\tilde{c},\tilde{q})}{\text{Var}(\tilde{q})}$, the regression coefficient of 'transitory' consumption on transitory income

Consumption identification

Full Identification

We use GMM on the equations:

$$\mathrm{Var}(\Delta^N \bar{y_T}) = (N - \frac{1}{3})\sigma_p^2 + 2\sigma_{\tilde{q}}^2$$

$$\mathrm{Cov}(\Delta^N \bar{c_T}, \Delta^N \bar{y_T}) = \phi(N - \frac{1}{3})\sigma_p^2 + 2\psi\sigma_{\tilde{q}}^2$$

with $N = 3, 4, 5$ (and $T = 2007, .., 2015$) to identify the four unknowns:

- σ_p^2: Permanent shock variance
- $\sigma_{\tilde{q}}^2$: (Time aggregated) transitory shock variance
- ϕ: MPX out of permanent income shocks
- ψ: MPX out of transitory income shocks

Marginal **P**ropensity to e**X**pend (includes durables) Methodology intuition

Data

What we need:

- Panel Data on Income and Expenditure
- Household Balance Sheet Data (detail on nominal assets)

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Income:

- Starting point: Register based micro data for all Danish households made available by Statistics Denmark
  - We use after-tax income for the household head, based on third-party reported tax data
  - Restrict sample to heads aged 30-55
- We divide through by permanent income (mean income over all observed years) and take the residual after controlling for age, education, marital status etc. (along with interactions of these)

Data: Expenditure

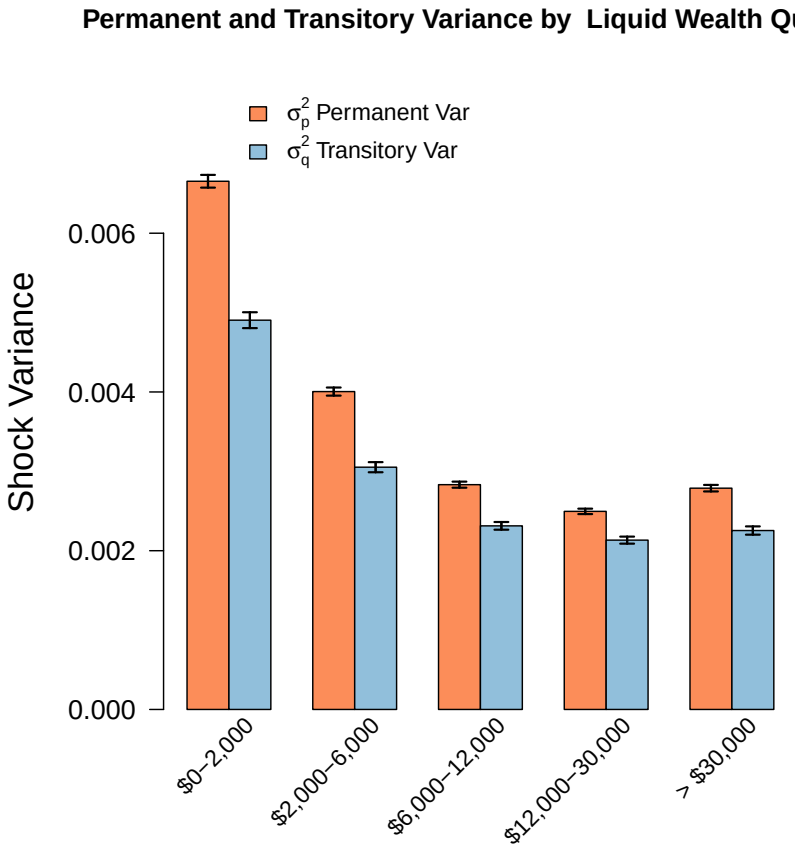
We impute expenditure from the budget constraint

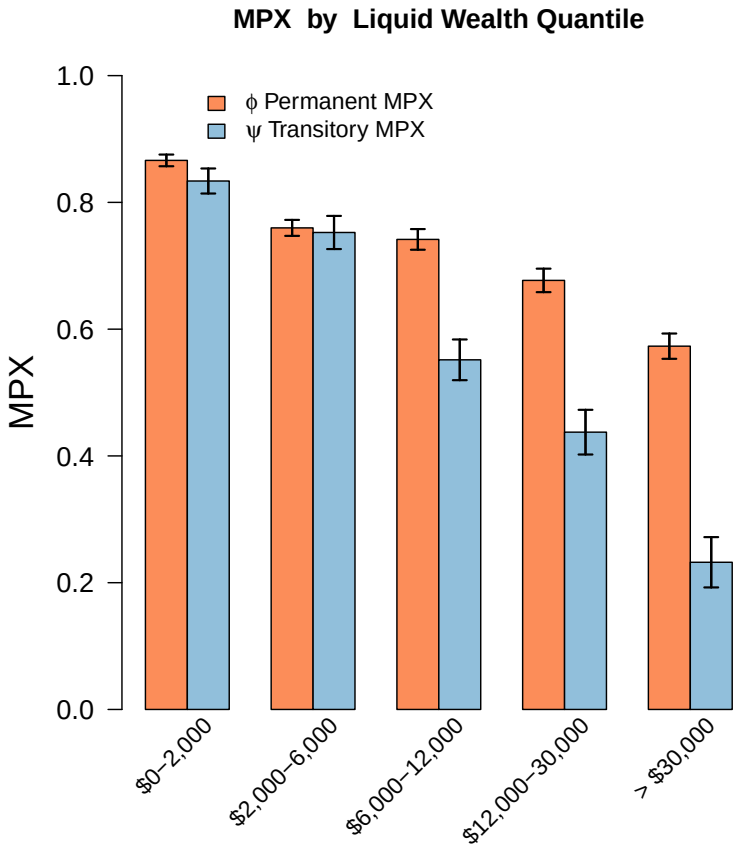
$$C_t \equiv Y_t - S_t = Y_t - P_t - \Delta NW$$

- Deposit and brokerage accounts all third party reported
- Works well for households with simple financial lives
- Main issue: Capital gains and losses
  - Exclude households where methodology will not work well (eg business owners)
  - Exclude housing wealth and years with housing transactions
  - Capital gains for stocks based on a diversified index
- Noisy, but perhaps better than surveys (Abildgren, Kuchler, Rasmussen, and Sorensen (2018))
- Huge sample size advantage: sample covers 7.6 million observations over 2004-2015

On measurement error

Results by Liquid Wealth





MPX by Net Wealth

Monetary Policy: Auclert's Decomposition

How does Monetary Policy Affect Aggregate Consumption?

- Intertemporal Substitution
- Aggregate Income

} Representative Agent Channels

Monetary Policy: Auclert's Decomposition

→ Dominates in Rep. Agent NK models

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→ Large in Spender-Saver, or TANK models

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- Fisher (Inflationary debt relief)
- Earnings Heterogeneity
- Interest Rate Exposure

} Redistribution Channels

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} Redistribution Channels

How can we *empirically* measure the size of the redistribution channels?

Need to know the distribution of MPCs along the relevant dimension of redistribution

Interest Rate Exposure: Auclert's Experiment

- Real interest rate increases 1 pp. for 1 year
- Hold constant income and inflation

How does the subsequent redistribution impact aggregate consumption?

Dimension of Redistribution: Unhedged Interest Rate Exposure

Interest Rate Exposure: Dimension of Redistribution

Define **Unhedged Interest Rate Exposure** for household i as the total savings the household will invest at this year's interest rate:

$$URE_i = Y_i - C_i + A_i - L_i$$

Where

- Y_i = Total after tax income
- C_i = Total Expenditure, including interest payments
- A_i = Maturing assets
- L_i = Maturing liabilities

Following a change in the interest rate dR, the size of the Interest Rate Exposure channel on household i's expenditure is:

$$dc_i = MPC_i URE_i \frac{dR}{R}$$

Interest Rate Exposure: Aggregation

Aggregate to find size of channel:

$$dc_i = MPC_i URE_i \frac{dR}{R}$$

$$\Longrightarrow \frac{dC}{C} = \mathbb{E}_I\left(MPC_i \frac{URE_i}{\mathbb{E}_I(c_i)}\right)\frac{dR}{R}$$

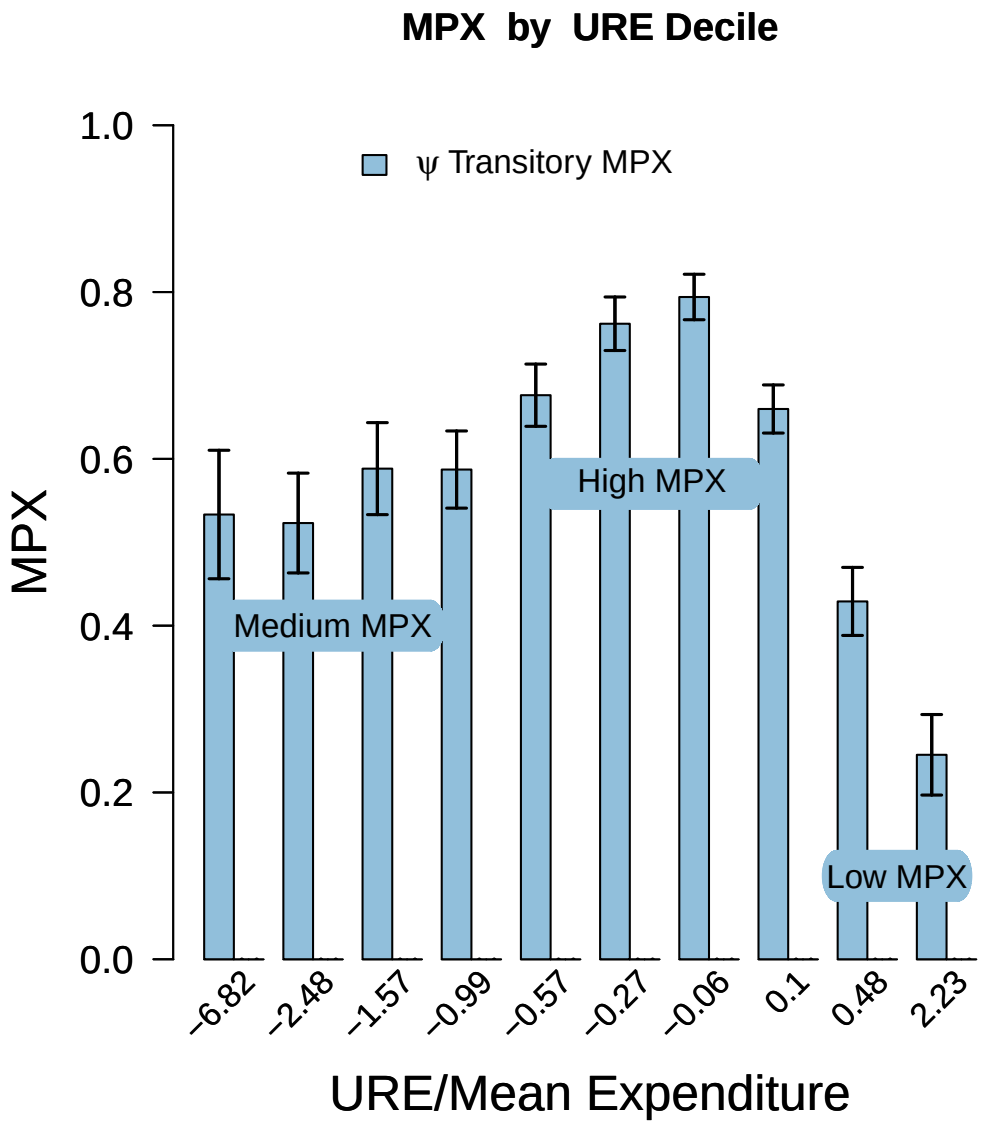
Define sufficient statistic:

$$\mathcal{E}_R = \mathbb{E}_I\left(MPC_i \frac{URE_i}{\mathbb{E}_I(c_i)}\right)$$

$\Longrightarrow$ Need to know the distribution of MPC_i with URE_i

We can do that!

Interest Rate Exposure: MPX Distribution



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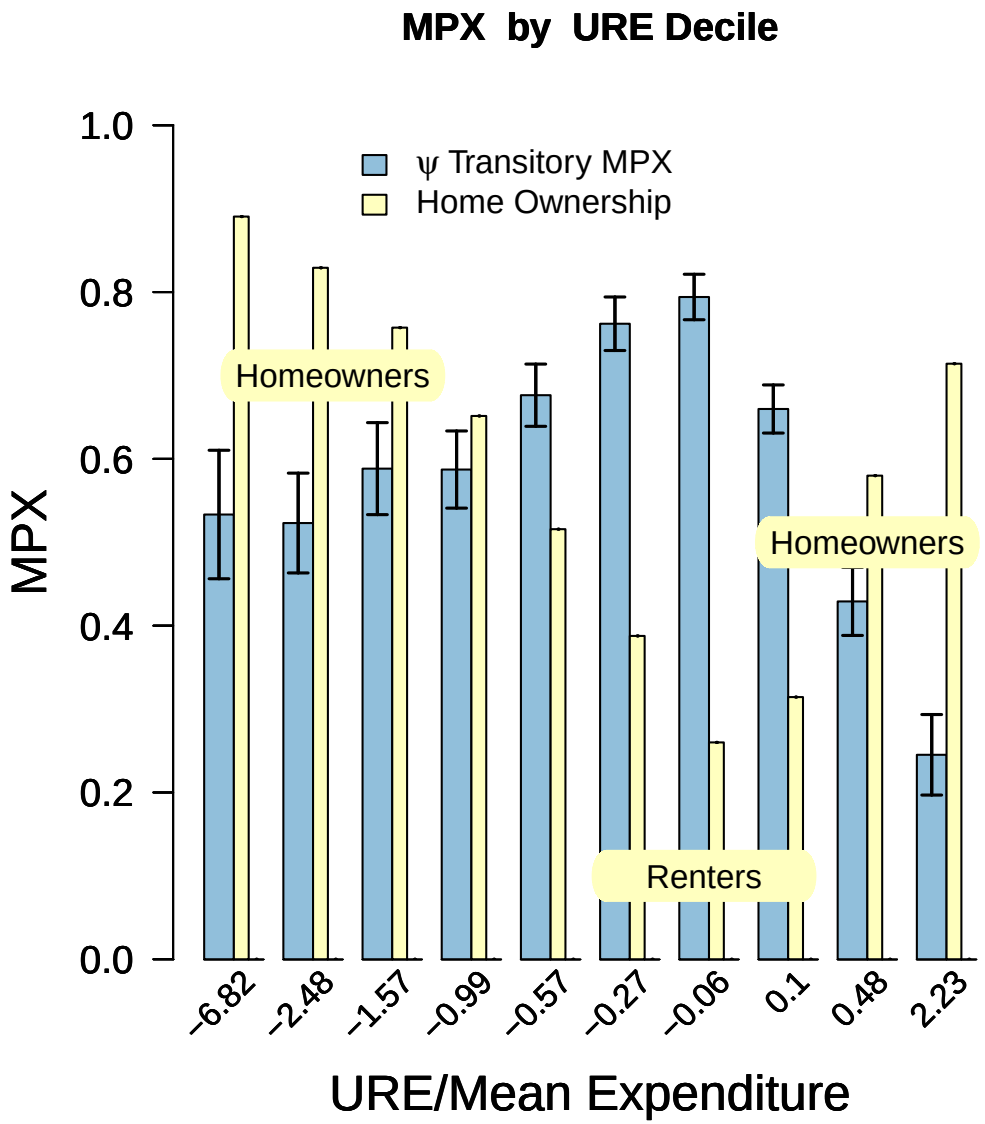

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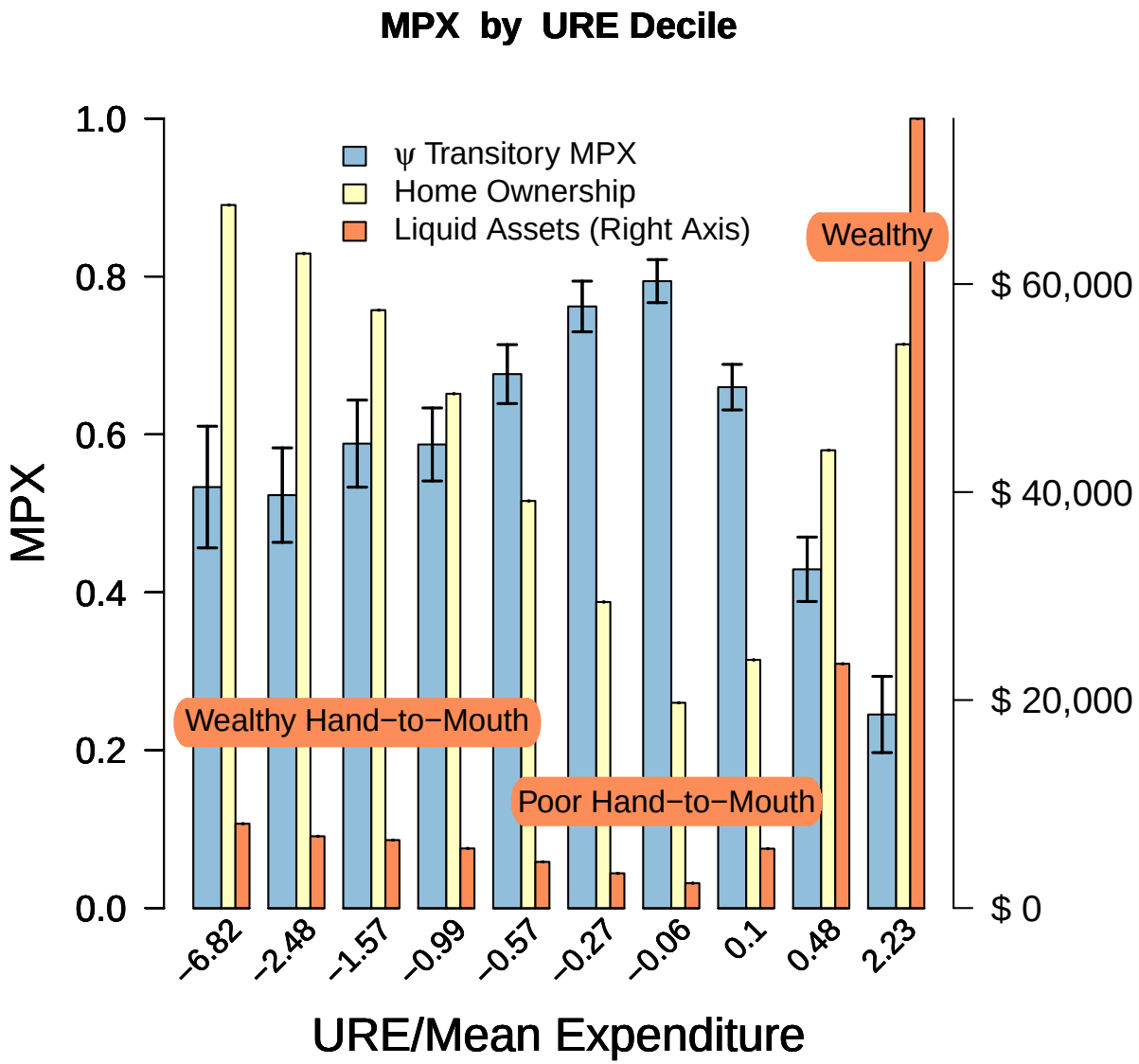

Interest Rate Exposure: Out of Sample

Total URE sums to zero - this is not true for our household sample

- -61bn USD

	MPX	URE	$\mathcal{E}_R$ component
Estimation Sample	**See Distribution**	**-61**	**-0.29**
Young	0.5	-15	-0.06
Old	0.5	6	0.02
Pension Funds	0.1	37	0.03
Government	0.0	-23	0.00
Non-financial Corp.	0.1	-13	-0.01
Financial Sector	0.1	61	0.05
Rest of World	0.0	9	0.00
Total		**0**	**-0.26**

Notes: URE numbers are in billions of 2015 USD.

All Five Transmission Channels

$$\frac{dC}{C} = \overbrace{\mathcal{M}\frac{dY}{Y}}^{\text{Aggregate Income Channel}} \overbrace{+\gamma\mathcal{E}_Y\frac{dY}{Y}}^{\text{Earnings Heterogeity Channel}} \overbrace{-\mathcal{E}_P\frac{dP}{P}}^{\text{Fisher Channel}} \underbrace{+\mathcal{E}_R\frac{dR}{R}}_{\text{Interest Rate Exposure Channel}} \underbrace{-\sigma\mathcal{S}\frac{dR}{R}}_{\text{Intertemporal Substitution Channel}}$$

$\mathcal{M}$	0.52
$\mathcal{E}_Y$	-0.03
$\mathcal{E}_P$	-0.75
$\mathcal{E}_R$	-0.26
$\mathcal{S}$	0.49

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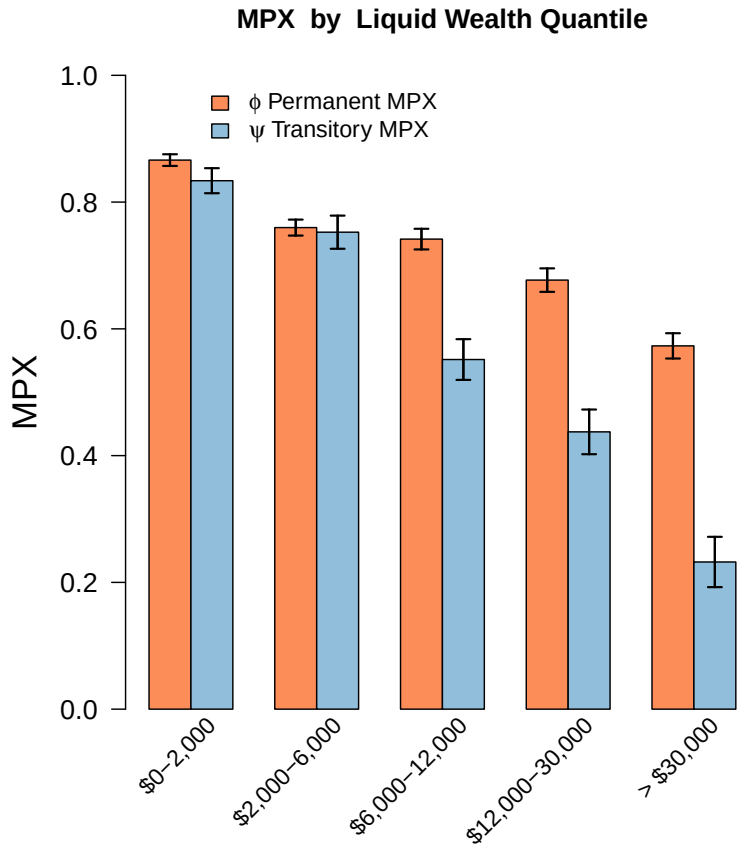
Compare $\mathcal{E}_R$ to σS:

σ in the range of 0.1 to 0.5 (maybe)

$\sigma S \approx 0.05 - 0.25$

Aim of Modeling Exercise

Can we calibrate a standard Buffer-Stock saving model to fit the distribution of MPC with liquid wealth?

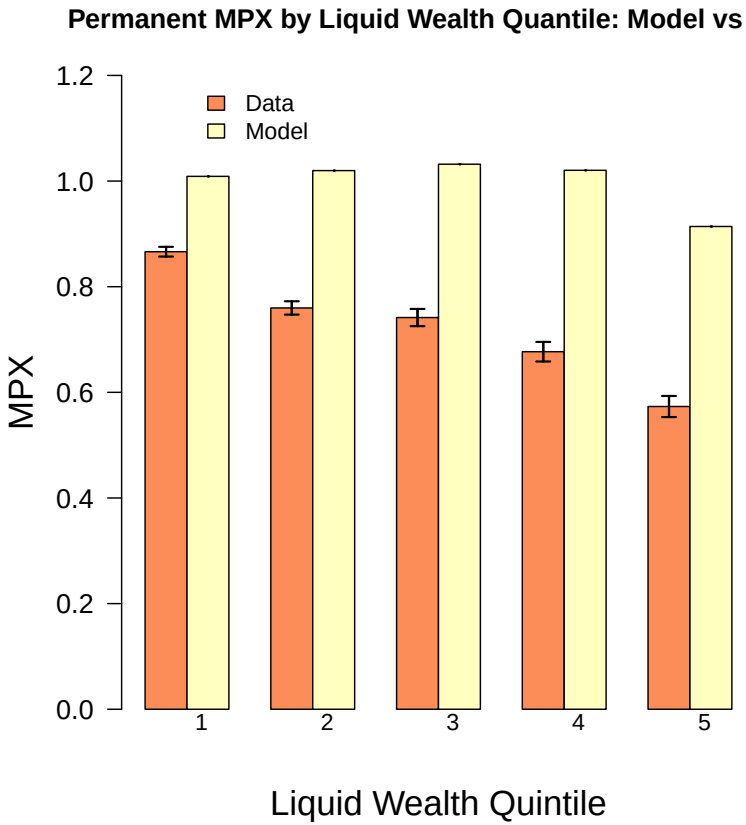


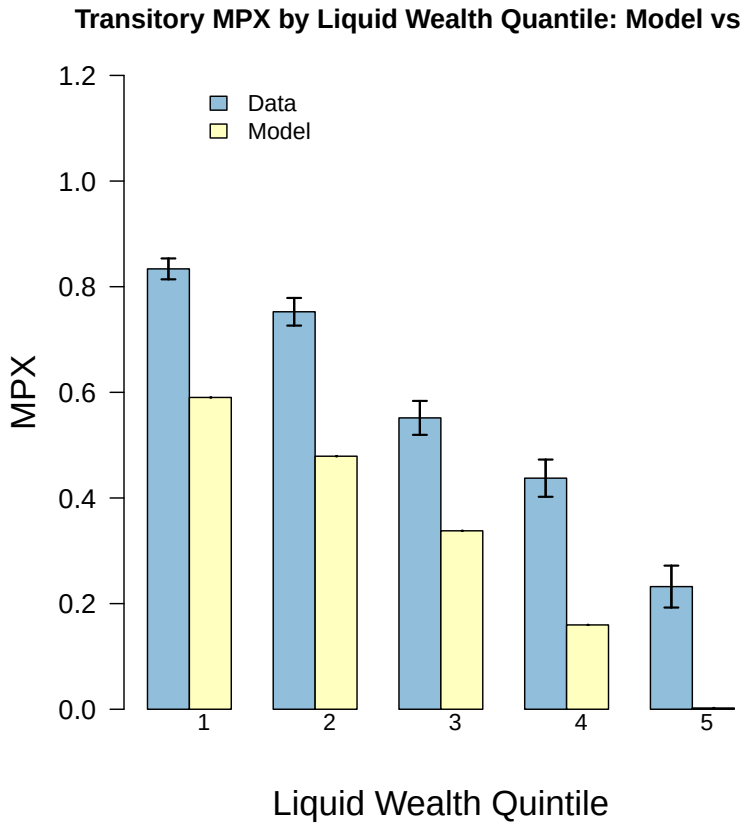
Key features:

- High overall Transitory MPC
- Decreasing with liquid wealth

Model details

Taste Shock Model: Results





Conclusion

- We have designed a new method to estimate consumption responses to income shocks
- It appears to work well, both in theory and practice
- We can use it to show that heterogeneity plays a key role in monetary policy transmission

Thank you!

Durables

We have data on value of household cars

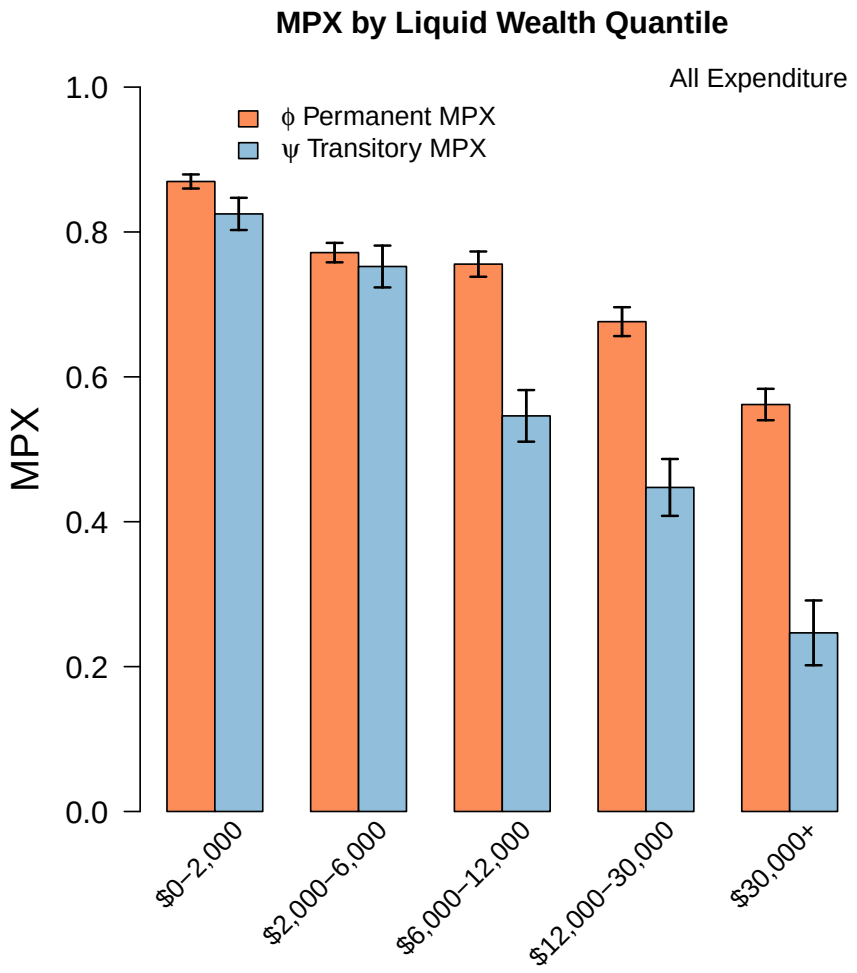
- Construct expenditure excluding car purchases and sales

$$C_T^{\text{nocar}} = C_T - \Delta\text{CarValue}$$

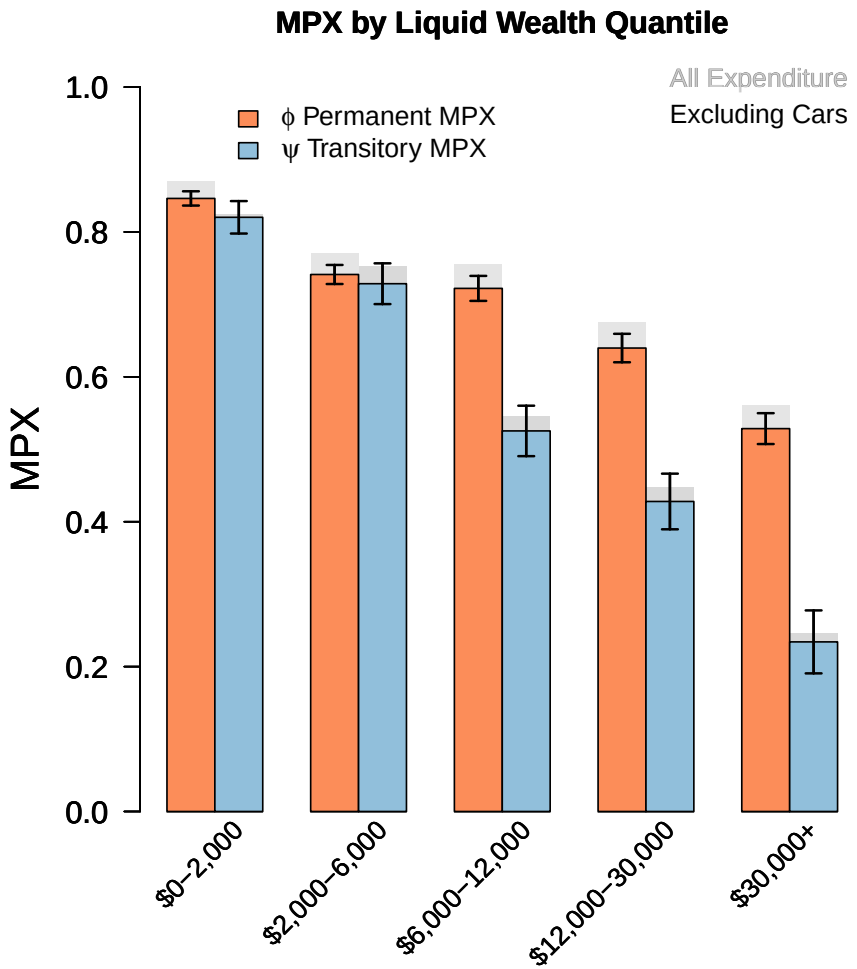
- Construct proxy for non durable consumption (Cars $\approx 42.1\%$ durable expenditure)

$$C_T^{\text{nondurable}} = C_T - \frac{1}{0.421}\Delta\text{CarValue}$$

Durables


MPX by Liquid Wealth Quantile
All Expenditure
ϕ Permanent MPX
ψ Transitory MPX
MPX
1.0
0.8
0.6
0.4
0.2
0.0
$0–2,000
$2,000–6,000
$6,000–12,000
$12,000–30,000
$30,000+

Durables


MPX by Liquid Wealth Quantile
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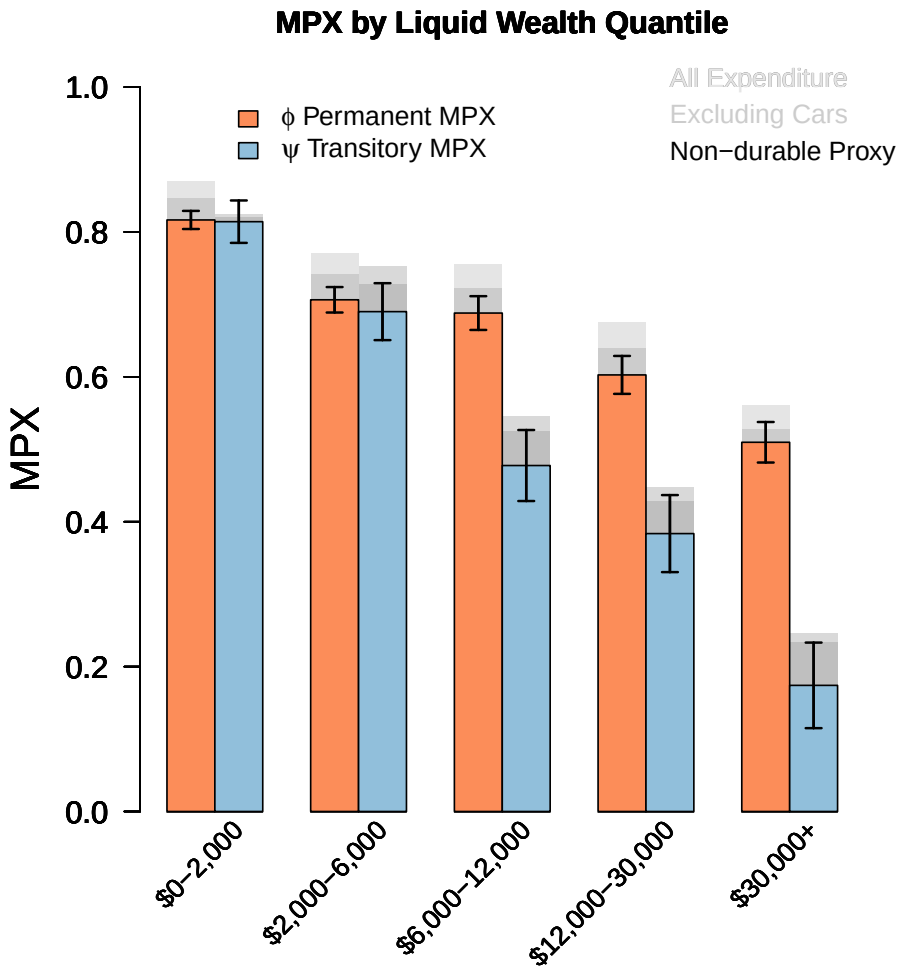
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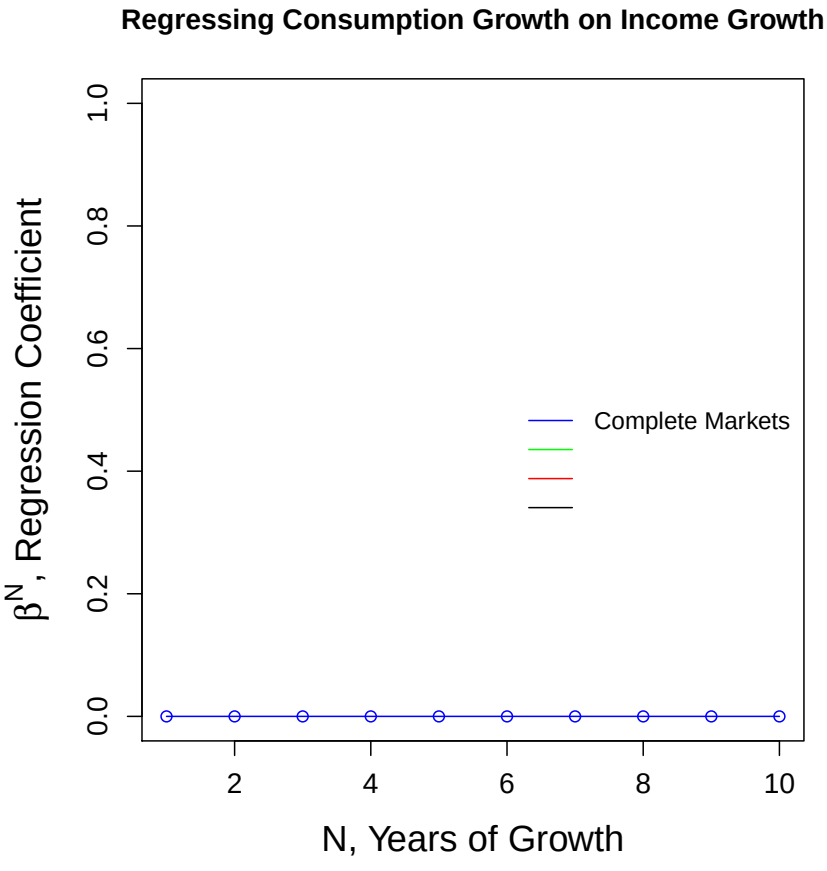
Methodology Intuition and Suggestive Findings

Exploit increasing importance of permanent shocks as the time over which growth is measured increases



$$\Delta^N c_i = \alpha^N + \beta^N \Delta^N y_i + \varepsilon_i$$

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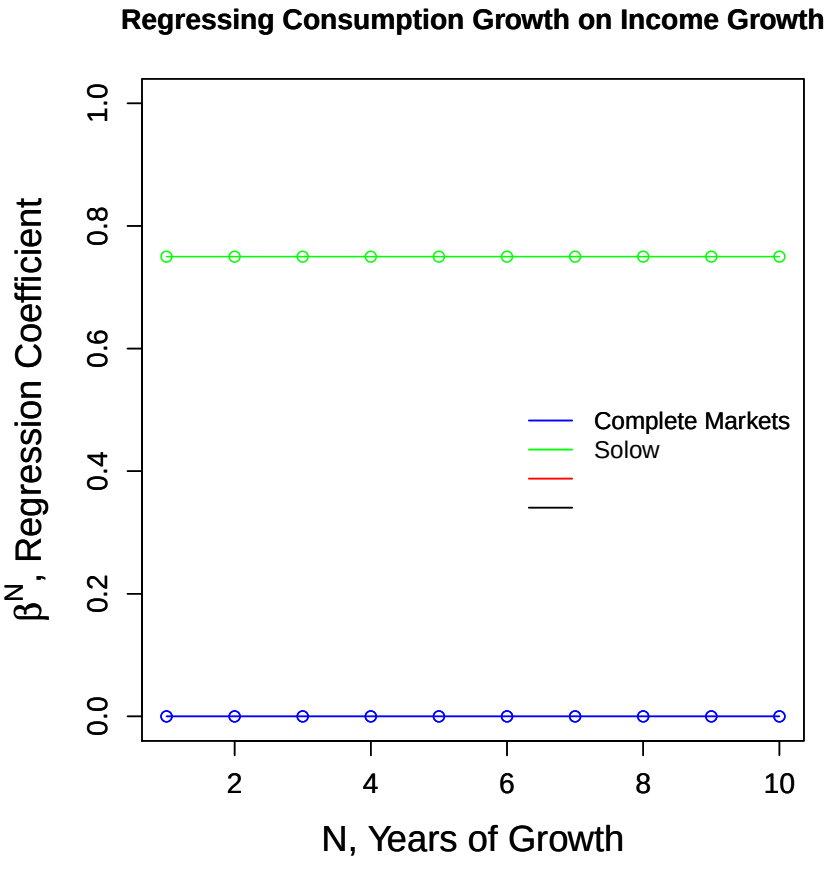

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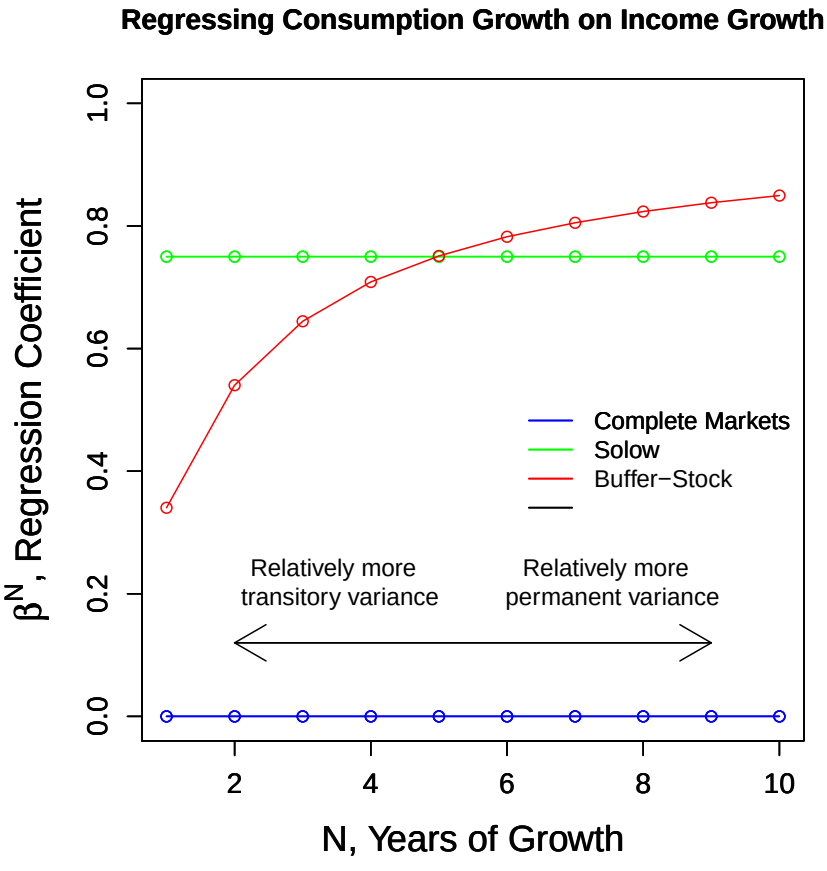

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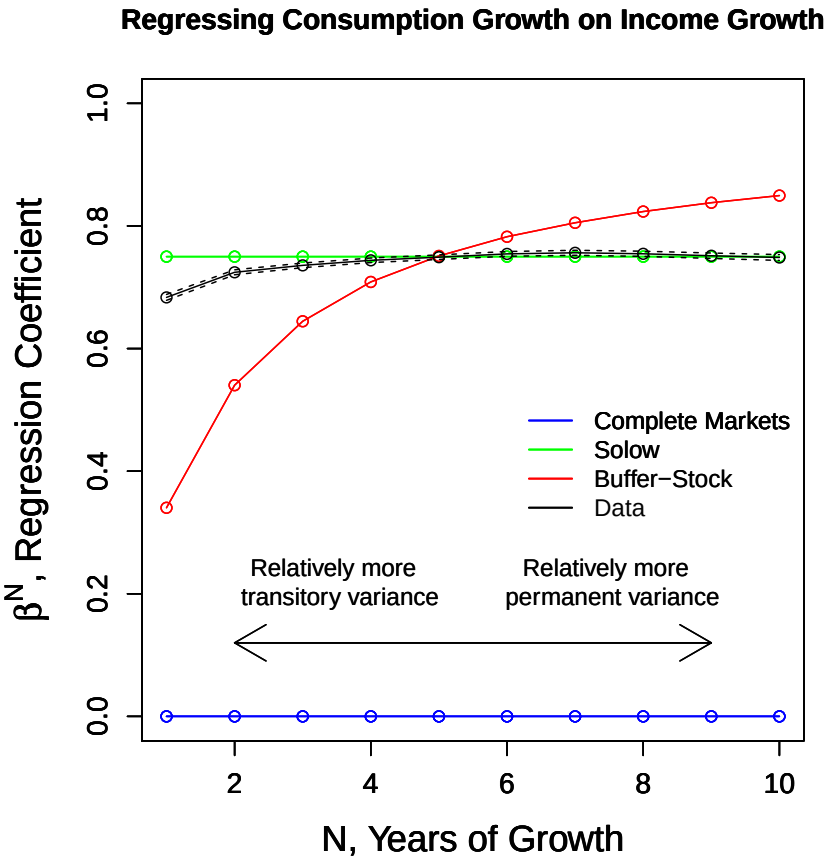

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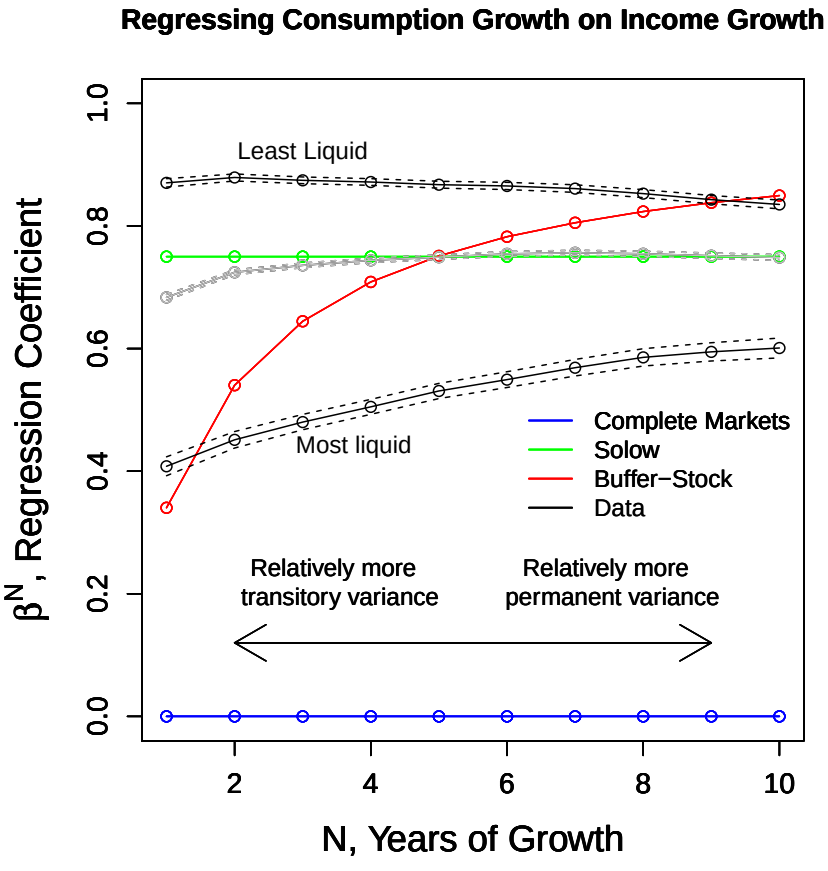

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Aside: Why Not Blundell, Pistaferri and Preston 2008?

Common Assumptions

Income y_t is made up of:

- Permanent Income (random walk)
- Transitory Income (uncorrelated over time)

Key to BPP Identification

Δy_{t+1} is a *valid instrument* for transitory shocks in year t

- Negatively correlated with transitory shocks in year t
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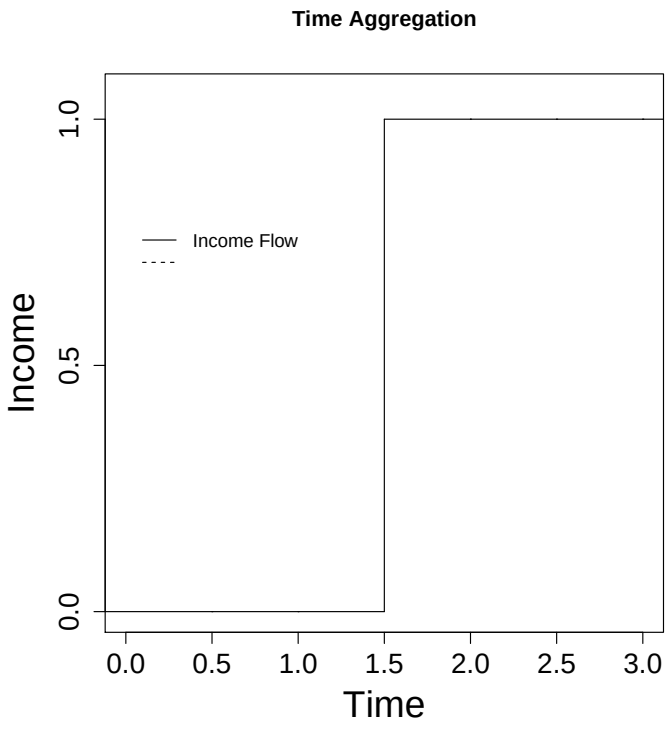
Fails due to the **Time Aggregation Problem** Time aggregation problem

Time Aggregation Problem (Crawley 2018)



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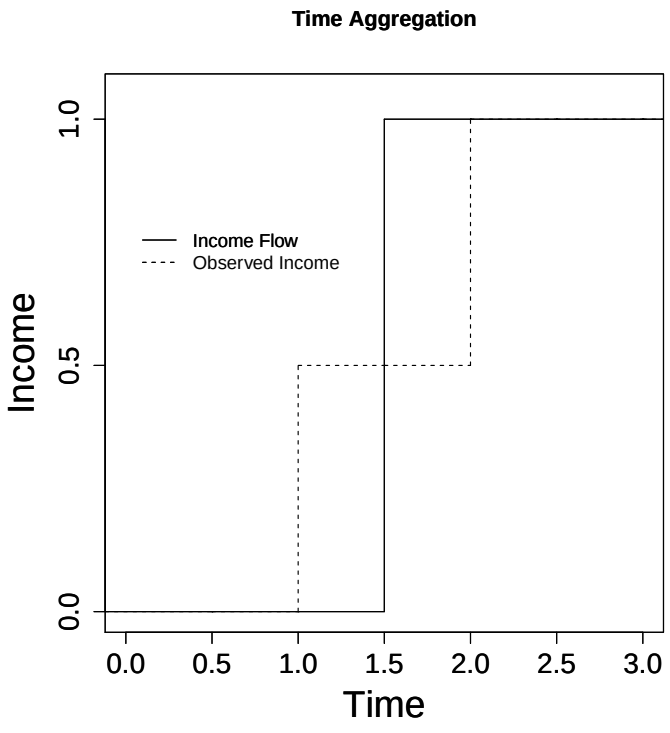

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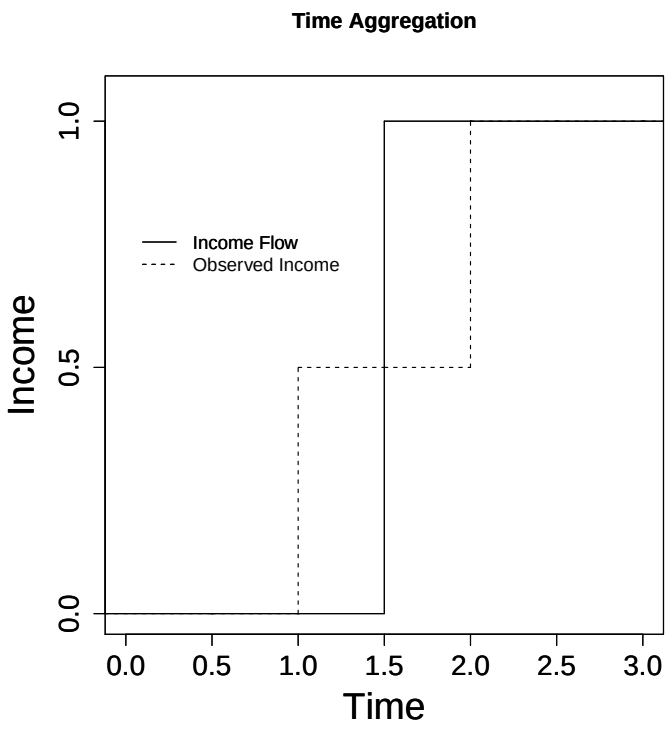

Observed permanent income growth is *positively* autocorrelated

BPP misinterprets *positive* permanent income shocks as *negative* transitory shocks

$\Longrightarrow$ Thinks negative transitory shocks result in consumption *increasing*

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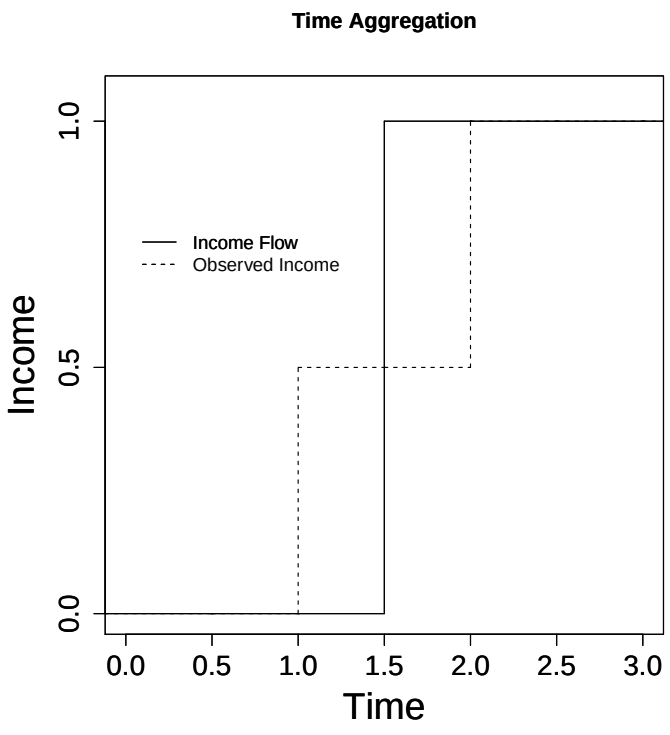

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If the Permanent Income Hypothesis holds, BPP will estimate the MPC to be -0.6

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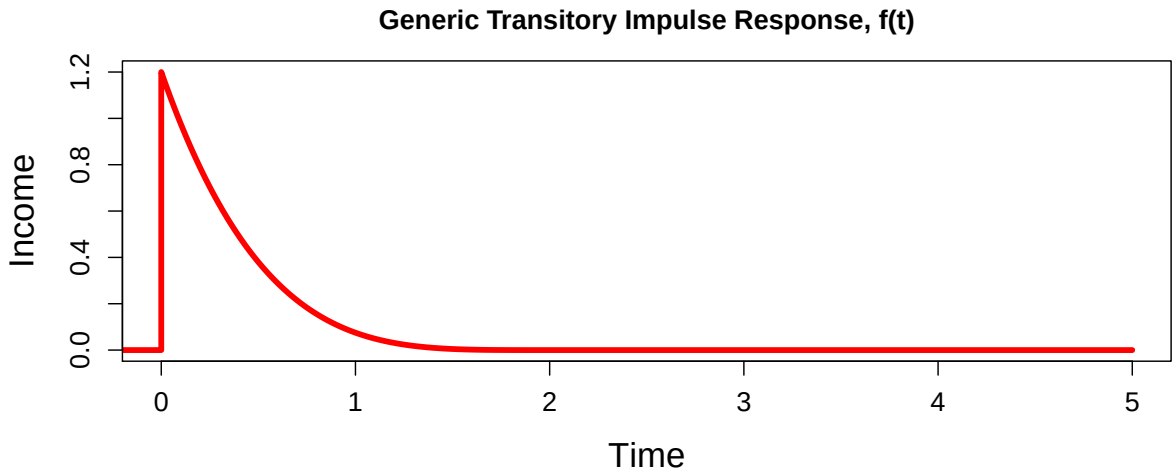
- Transitory Income (persistence $<$ 2 years)



$$y_t = p_t + \int_{t-2}^{t} f(t-s)dq_s$$

Permanent income flow

Transitory income flow

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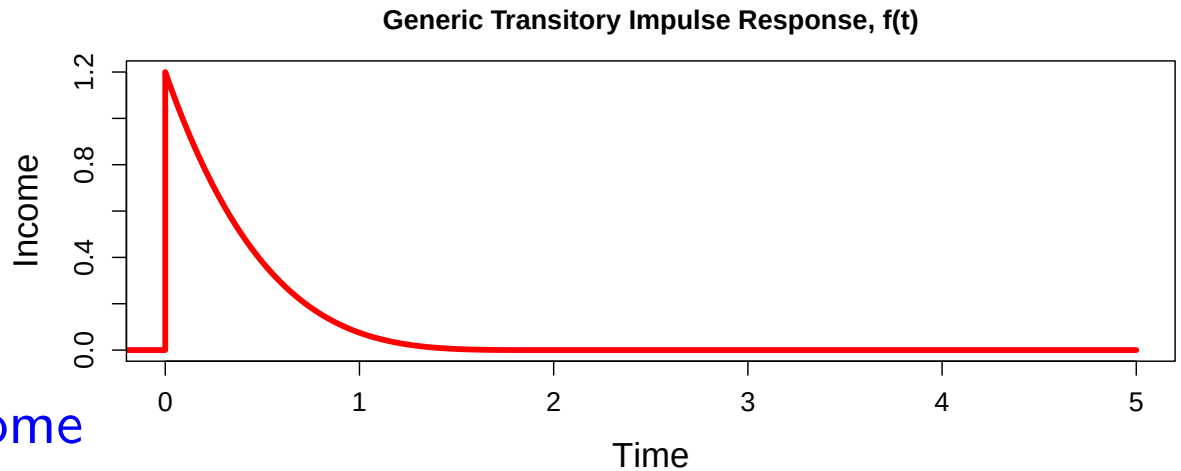

Observed Income

$$\uparrow$$

$$\bar{y}_T = \int_{T-1}^{T} y_t dt = \int_{T-1}^{T} p_t dt + \int_{T-1}^{T} \int_{t-2}^{t} f(t-s) dq_s dt$$

$$\downarrow$$

Time Aggregation

Identification Restrictions: Income

$$\bar{y}_T = \int_{T-1}^{T} p_t dt + \int_{T-1}^{T} \int_{t-2}^{t} f(t-s) dq_s dt$$

$$\begin{aligned}
\Delta^N \bar{y}_T &= \bar{y}_T - \bar{y}_{T-N} \\
&= \int_{T-1}^{T} (p_t - p_{T-1}) dt \quad - \int_{T-N-1}^{T-N} (p_t - p_{T-N}) dt \\
&\quad + (p_{T-1} - p_{T-N}) \\
&+ \int_{T-1}^{T} \int_{t-2}^{t} f(t-s) dq_s dt \quad - \int_{T-N-1}^{T-N} \int_{t-2}^{t} f(t-s) dq_s dt
\end{aligned}$$

Independent increments

$\mathrm{Var} = (\frac{1}{3} + \frac{1}{3} + N - 1)\sigma_p^2$

Identification Restrictions: Income

$$\bar{y}_T = \int_{T-1}^{T} p_t dt + \int_{T-1}^{T} \int_{t-2}^{t} f(t-s) dq_s dt$$

$$\begin{aligned}
\Delta^N \bar{y}_T &= \bar{y}_T - \bar{y}_{T-N} \\
&= \int_{T-1}^{T} (p_t - p_{T-1}) dt \quad - \int_{T-N-1}^{T-N} (p_t - p_{T-N}) dt \\
&\quad + (p_{T-1} - p_{T-N}) \\
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\end{aligned}$$

Independent increments
$\text{Var} = (\frac{1}{3} + \frac{1}{3} + N - 1)\sigma_p^2$

Independent if $N \geq 3$

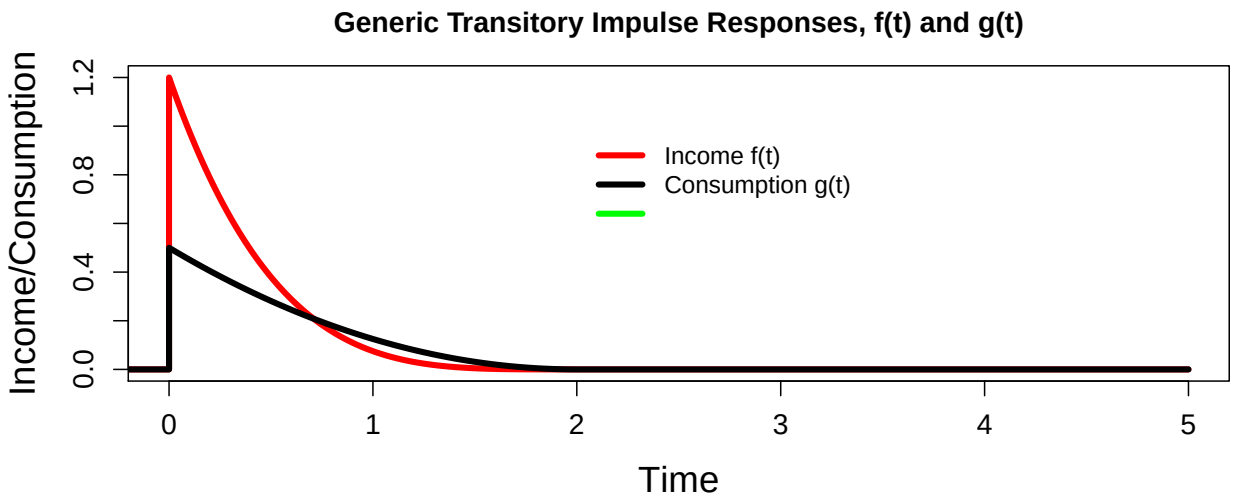
$$\implies \text{Var}(\Delta^N \bar{y}_T) = (N - \frac{1}{3})\sigma_p^2 + 2\sigma_{\tilde{q}}^2 \text{ for } N \geq 3$$

Identification Restrictions: Consumption

Assumptions on Consumption

- Permanent: Consumption permanently moves by fraction ϕ of the income shock
- Transitory: Persistence $<$ 2 years

Evidence



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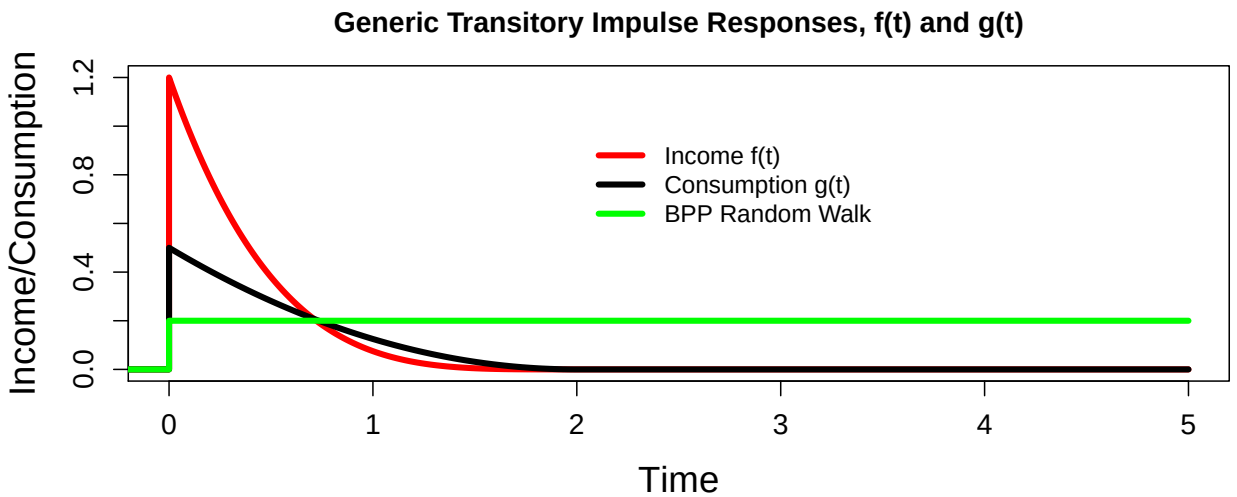

This is a key difference between what we assume and BPP

Identification Restrictions: Consumption

Consumption flow is given by:

$$c_t = \phi p_t + \int_{t-2}^{t} g(t-s)dq_s$$

$$\implies \text{Cov}(\Delta^N \bar{c_T}, \Delta^N \bar{y_T}) = \phi(N - \frac{1}{3})\sigma_p^2 + 2\psi\sigma_{\tilde{q}}^2$$

where $\psi = \frac{\text{Cov}(\tilde{c},\tilde{q})}{\text{Var}(\tilde{q})}$, the regression coefficient of 'transitory' consumption on transitory income

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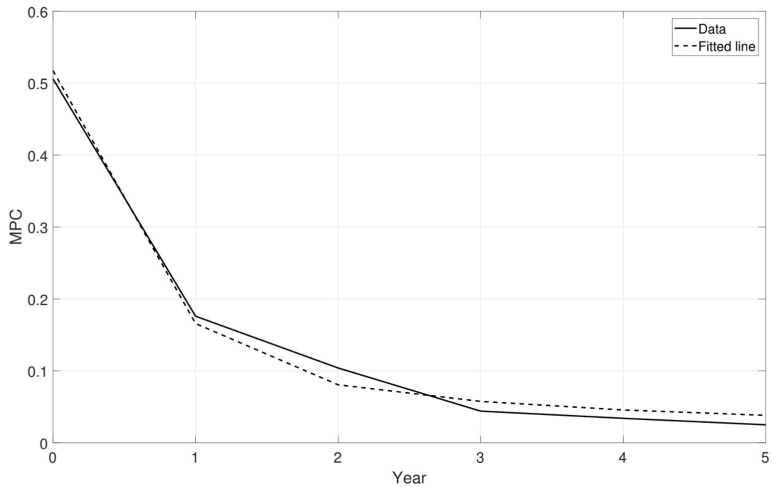
- ϕ: MPX out of permanent income shocks
- ψ: MPX out of transitory income shocks

Marginal **P**ropensity to e**X**pend (includes durables)

Evidence of Consumption Decay Within 2 Years

From Fagereng, Holm, and Natvik (2016)



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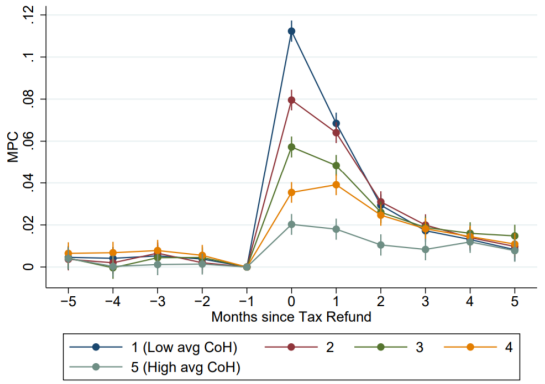
From Gelman (2016)

Figure 10: Tax refund impulse response function



Notes: 1,445,560 observations from 48,059 individuals. The vertical bars on each coefficient represent 95% confidence intervals using heteroskedasticity robust errors clustered at the individual level.

Data: When is Measurement Error a Problem?

Our method has the same measurement error issues as the regressions:

$$\Delta^N c_i = \alpha^N + \beta^N \Delta^N y_i + \varepsilon_i$$

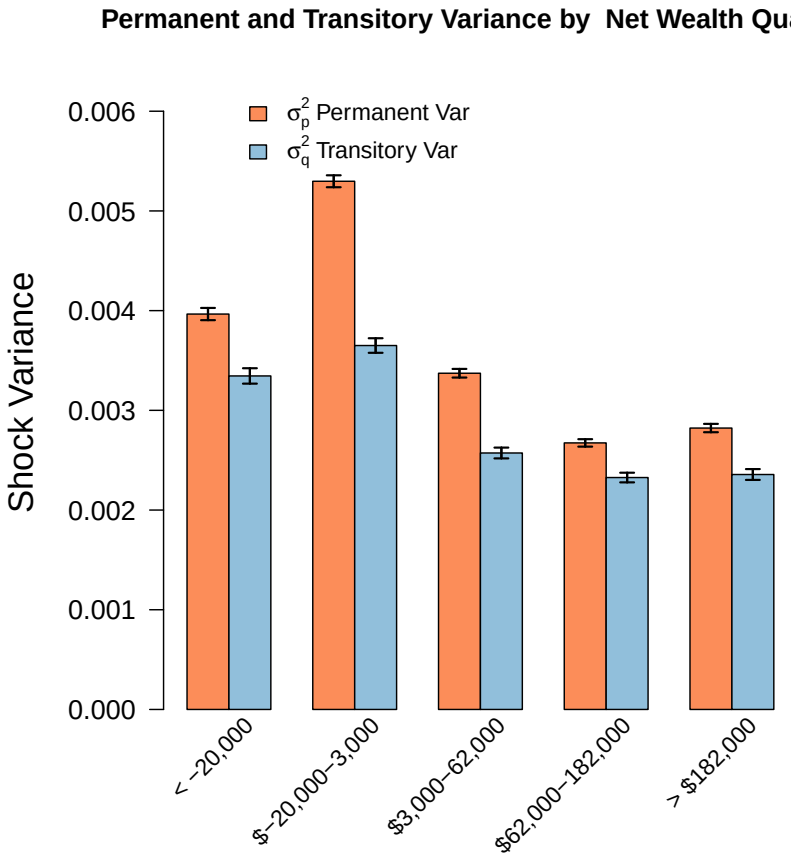
That is:

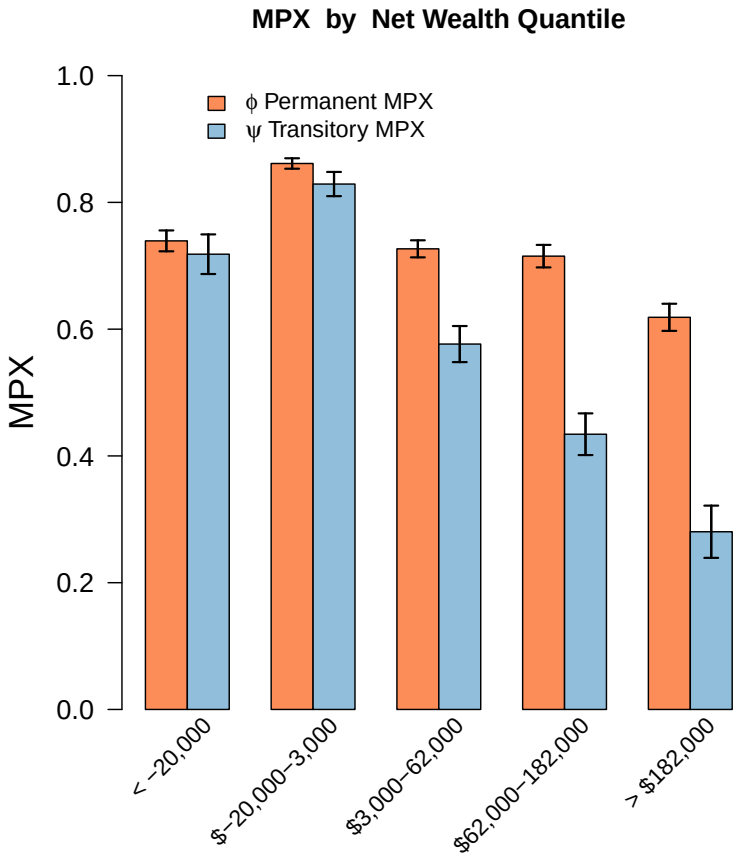
1. Measurement error in $\Delta^N y_i$ leads to attenuation bias
2. Measurement error in $\Delta^N c_i$ should be uncorrelated with $\Delta^N y_i$

When might 2 fail?

- When a proportion of assets are held off balance sheet
- When returns are correlated with *changes* in income (e.g. own stock in the company you work for)
- When insurance is provided by friends and family

MPX by Net Wealth





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